Low-Mass Planar Photonic Imaging Sensor

Completed Technology Project (2014 - 2016)

Project Introduction

We propose a revolutionary electro-optical (EO) imaging sensor concept that provides a low-mass, low-volume alternative to the traditional bulky optical telescope and focal plane detector array. This imaging sensor concept consists of millions of direct detection white-light interferometers densely packed onto photonic integrated circuits (PICs) to measure the amplitude and phase of the visibility function at spatial frequencies that span the full synthetic aperture. Our approach replaces the large optics and structures required by a conventional telescope with PICs based on emerging photonic technologies that are produced by standard lithographic fabrication techniques (e.g., CMOS fabrication). By integrating advanced optical interferometry and photonics technologies, this new EO imaging sensor concept enables exciting new NASA missions since it provides a large-aperture, wide-field EO imager at a fraction of the cost, mass and volume of conventional space telescopes. As part of the Phase II investigations, we will study several areas tailored to potential NASA missions and requirements. These studies include (1) investigate major feasibility issues associated with the cost, performance, development time, and key technologies related to SPIDER in NASA missions, (2) provide image simulations for a variety of SPIDER design configurations for three important next generation NASA missions; Europa, Mars Reconnaissance orbiter (MRO), and near-Earth orbit (NEO) detection, (3) develop a technology roadmap that includes key risk mitigation activities that address NASA mission needs, (4) leverage DARPA funded efforts to pursue photonic spectrometer risk mitigation experiments. The work will leverage recent efforts at UC Davis and Lockheed Martin that include NIAC Phase I and DARPA program activities. In Phase II, we will continue to investigate, demonstrate, and report on a non-traditional EO telescope with photonic imager for the Jupiter icy moons orbiter reference mission. Highly complementary to that work, in Phase II we will investigate SWIR integrated photonic spectrometer instruments to support the low size, weight, and power requirements for multiple NASA missions. We will use the momentum and knowledge gained in Phase I, to develop a high-resolution, low-SWaP imager concept for the NASA MRO mission and an imager and spectrometer for the NASA NEO detect and characterization mission.

Anticipated Benefits

These studies include (1) investigate major feasibility issues associated with the cost, performance, development time, and key technologies related to SPIDER in NASA missions, (2) provide image simulations for a variety of SPIDER design configurations for three important next generation NASA missions; Europa, Mars Reconnaissance orbiter (MRO), and near-Earth orbit (NEO) detection, (3) develop a technology roadmap that includes key risk mitigation activities that address NASA mission needs, (4) leverage DARPA funded efforts to pursue photonic spectrometer risk mitigation experiments. The work will leverage recent efforts at UC Davis and Lockheed Martin that include NIAC Phase I and DARPA program activities. In Phase II, we will

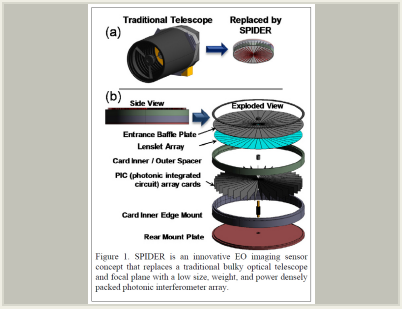


Figure 1. SPIDER is an innovative EO imaging sensor concept that replaces a traditional bulky optical telescope and focal plane with a low size, weight, and power densely packed photonic interferometer array.

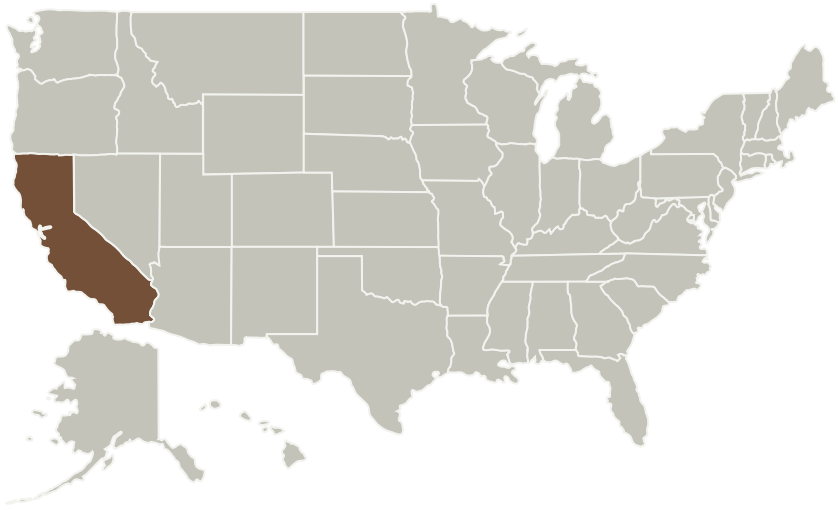
Low-Mass Planar Photonic Imaging Sensor

Table of Contents

Project Introduction	1
Anticipated Benefits	1
Primary U.S. Work Locations and Key Partners	2
Project Transitions	2
Organizational Responsibility	2
Project Management	2
Images	3
Technology Maturity (TRL)	3
Technology Areas	3
Target Destinations	3

continue to investigate, demonstrate, and report on a non-traditional EO telescope with photonic imager for the Jupiter icy moons orbiter reference mission.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
University of California-Davis(UC Davis)	Lead Organization	Academia	Davis, California
Lockheed Martin Inc.	Supporting Organization	Industry	Palo Alto, California

Primary U.S. Work Locations
California

Project Transitions

August 2014: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

University of California-Davis (UC Davis)

Responsible Program:

NASA Innovative Advanced Concepts

Project Management

Program Director:

Jason E Derleth

Program Manager:

Eric A Eberly

Principal Investigator:

Ben Yoo

Co-Investigators:

Alan Duncan
Ryan P Scott

Low-Mass Planar Photonic Imaging Sensor

Completed Technology Project (2014 - 2016)

July 2016: Closed out

Closeout Summary: Continuing on the successful progress of NIAC Phase I, thi s report summarizes the technical progress achieved under NIAC Phase II durin g the performance period September 19, 2014 -June 18, 2017. During this perio d, the research team has made the following accomplishments: • designed and l ayout a silica photonic integrated circuit (PIC) as a two baseline interferometric i mager, • constructed an experiment to utilize the two baselines for complex visi bility measurement on a point source and a variable width slit, • analyzed and st udied the testbed results. (in collaboration with Lockheed Martin), • designed an d layout Si3N4 PICs for the low-resolution and high-resolution SPIDER telescope , • fabricated the multi-layer Si3N4 PIC for low and high resolution SPIDER teles cope, • characterize the optical throughput and heater response for Si3N4 PIC fo r low and high resolution SPIDER telescopes, • carried out imaging experiments using the Si3N4 PIC low-resolution version (in collaboration with Lockheed Marti n), • investigated signal-to-noise (SNR) ratio of SPIDER imager compared to the conventional panchromatic imager (in collaboration with Lockheed Martin), • fulf illed the SNR simulation upon SPIDER imager (in collaboration with Lockheed Ma rtin).

Images

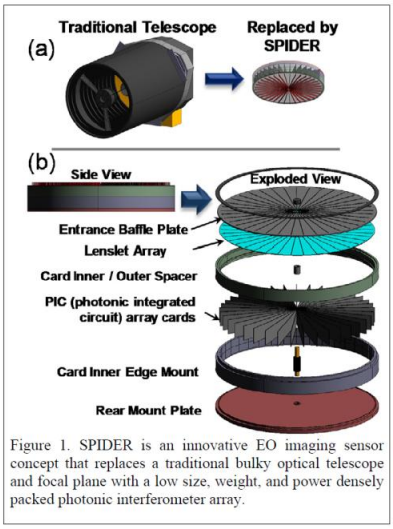
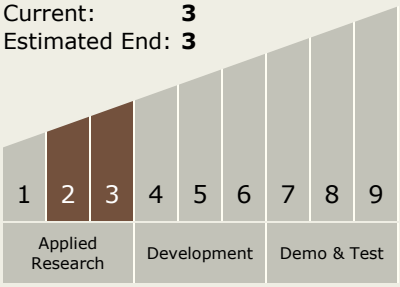


Figure 1. SPIDER is an innovative EO imaging sensor concept that replaces a traditional bulky optical telescope and focal plane with a low size, weight, and power densely packed photonic interferometer array.

Low-Mass Planar Photonic Imaging Sensor Concept
Low-Mass Planar Photonic Imaging Sensor
(https://techport.nasa.gov/image/102093)

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.3 Optical Components

Target Destinations

Mars, Earth, Others Inside the Solar System